~~limited distribut~~ ANN 86

NANTICOKE AREA EMISSIONS STUDY

EMISSION OF PARTICULATE MATTER,

SULPHUR DIOXIDE, NITROGEN OXIDES

TRACE ELEMENTS AND HYDROCARBONS

FROM THE STACKS OF THE

THREE MAJOR INDUSTRIES

IN THE

NANTICOKE AREA

REPORT No. ARB-71-86-ETRD

APRIL, 1986

Ministry of the Environment
Ontario

Dr. David Balsillie, Director
Air Resources Branch

NANTICOKE AREA EMISSIONS STUDY

EMISSIONS OF PARTICULATE MATTER, SULPHUR DIOXIDE, NITROGEN OXIDES TRACE ELEMENTS AND HYDROCARBONS FROM THE STACKS OF THE THREE MAJOR INDUSTRIES IN THE NANTICOKE AREA

REPORT NUMBER ARB-71-86-ETRD

by

Denis Maftei

Ontario Ministry of the Environment
Air Resources Branch
880 Bay Street, 4th Floor
Toronto, Ontario
M5S 1Z8

April 1986

TABLE OF CONTENTS

Page

LIST OF TABLES Page

ACKNOWLEDGEMENT

This report summarizes results obtained in programmes performed by, or under the direct supervision of, Ministry personnel. Many have been instrumental in the collection, analysis, and interpretation of the data contained herein and their efforts are gratefully acknowledged.

The Nanticoke Environmental Management Programme has funded most of the research and the contributions of the members: Environment Canada, Ontario Hydro, Ontario Ministry of the Environment, Stelco and Texaco are hereby recognized.

Arthur Gordon Environmental Evaluators performed stack sampling at both STELCO Inc. and Texaco Canada Inc. and the dedication of their team is credited for the quality of the results obtained.

The Inorganic Trace Contaminants section of the Laboratory Services Branch of the Ministry has been responsible for most of the analysis and their efforts are acknowledged.

The Source Assessment Unit of the Air Resources Branch has been involved in actual sampling (at Texaco) as well as planning and coordinating all the other source testing activities. All its members are recognized.

1 - INTRODUCTION

The Nanticoke Environmental Management Programme has been established to coordinate the environmental activities generated by the creation of a significant industrial concentration on the shores of Lake Erie in the Nanticoke area.

The area contains the largest coal-fired generating station in North America (4 000 MW), operated by Ontario Hydro, a completely integrated steelworks, with an initial capacity of 1.17 million tonnes per year and the potential to expand to 10.9 millions tonnes per year, built by STELCO Inc. and an oil refinery with a capacity of 105 000 bbl/day, erected by Texaco Canada Inc. The size of this development exceeded any other in Canada, including the Tar Sands Project and its impact needed to be assessed.

All three companies involved joined forces, together with Environment Canada and the Ontario Ministry of the Environment, to participate in a long range study encompassing all environmental effects of the proposed development upon the surrounding area, as well as, interactions with other industrial and residential concentrations in relative close proximity (i.e. Hamilton, Toronto, Buffalo, Cleveland, etc.)

Some of the main areas of study where NEMP concentrated its efforts included air quality, meteorology, processes for

natural removal of pollutants and real time monitoring.

The quantification of all atmospheric releases of contaminants of interest, is obviously one of the preconditions of establishing a workable model which describes the fate of these contaminants in the environment. It is in this area of emission quantification that the Source Measurement Unit of the Ministry has been active in the NEMP programme. This report documents the results.

The main pollutants of interest to NEMP were particulate matter, sulphur oxides, and nitrogen oxides. They are the "large tonnage" waste products of the processes taking place in the three industries under discussion. Also of interest were trace elements, some of which have effects disproportionate to their share of the total emissions.

The largest source, Ontario Hydro is also the one for which best estimates can be derived from emission factors. Data presented by the Company have been used as such and are reported here as received.

Stelco and Texaco have had all their stacks evaluated and the most significant have been chosen for exact quantitation by direct sampling. Two surveys, carried out in 1982 and 1983, at Texaco and Stelco, respectively, covered a total of eight major confined sources. In addition, Ministry personnel determined the hydrocarbon emissions from the tank farm at Texaco in a 1979 study. This report summarizes all the results obtained.

2 - SUMMARY

During a period of four and a half years, between the summer of 1979 and the end of 1983 the Source Measurement Unit of the Ministry of the Environment organized, supervised, and/or carried out directly, sampling at different confined sources of each of the three major industrial operations in the Nanticoke area.

The tank farm at Texaco has been found to emit close to one hundred (100) tonnes of hydrocarbons per year.

Emissions of particulate matter, sulphur oxides (expressed as SO_2) and nitrogen oxides (expressed as NO_2) from two major boilers in the Texaco refinery, the CO Boiler and the No. 1 Power Boiler, have been determined at three hundred and sixty-eight (368), nine thousand three hundred and twenty (9,320), and eight hundred and forty-one (841) tonnes per year, respectively. A fourth major source of SO_2 at the same location is the Sulphur Recovery Unit with emissions of sixteen hundred and thirty-seven (1,637) tonnes per year.

Stelco's Central Power Station Boilers and Coke Oven Quench Tower are the major emitters of particulate matter with annual (1983 - stack sampling) contributions of one hundred and forty-five (145) and five hundred and three (503) tonnes, respectively. The Power Boilers, Coke Oven

Underfiring and Blast Furnace Stoves emit nineteen hundred (1,900), six hundred (600), and two hundred (200) tonnes SO_2 per year, respectively. The same three sources emit thirteen hundred (1,300), seven hundred (700), and two hundred (200) tonnes NO_2 per year, respectively.

The total atmospheric emissions of Ontario Hydro in 1983, as reported by the Company, amounted to twenty-five hundred (2,500) tonnes of particulate matter, two hundred fifty thousand (250,000) tonnes of sulphur oxides and seventy-five thousand (75,000) tonnes of nitrogen oxides.

3 - DESCRIPTION OF SOURCES AND PROCESSES

The three industrial operations established in the Nanticoke area are described with special attention paid to their sources of gaseous and particulate matter emissions into the atmosphere. Only emissions from confined sources (i.e. stacks) have been considered in this report.

3.1 - GENERAL

The Nanticoke industrial development was started as one of the largest industrial developments in the world, with an investment exceeding that projected for the Alberta Oil Sands mining and refining operation up to the year 2000.

Its vicinity to several large urban areas within a radius of 100 miles, as well as, the effects that an undertaking of this magnitude was expected to have on a previously predominantly agricultural area, caused the initiation of a complex and detailed study under the aegis of the Nanticoke Environmental Management Programme. Members of this Programme were the three industries involved, i.e.: Ontario Hydro, Stelco Inc. and Texaco Canada Inc. and the federal and provincial governments.

The quantification of total emissions from the industrial sources was a main interest of the Programme, as

well as, a starting point in the process of solving other problems related to atmospheric dispersion and transport of pollutants.

This report is concerned with the results of the efforts to quantify emissions of the main contaminants from the three industries in Nanticoke by source sampling. The work has been performed at the request of NEMP by or under the supervision of the Source Assessment Unit of the Ontario Ministry of the Environment.

3.1.1 - ONTARIO HYDRO

Nanticoke Thermal Generating Station is the largest coal-fired station owned by Ontario Hydro. It consists of eight identically sized units, each rated at a generating capacity of 512 MW.

This power station is operated as a peaking station. That is, it is used to meet peak demands for electricity. During the winter, when demand is highest, the station may run at full capacity for days at a time. During the spring it may not operate at all on weekends when demand is lowest. At other times, it may go through a diurnal cycle of high use in midday and lower loads overnight. In 1983, it operated at an average of 53% of capacity. A short description of the equipment and process, as provided by Ontario Hydro[1], is given below.

Each unit has a Babcox and Wilcox boiler, of the waterwall, natural circulation type. At full load, the steam production is 453.6 kg/s, at 16.9 MPa and 538^{o}C. The steam is allowed to expand in turbines which drive three phase, 60 Hz generators. The condensate is continuously recycled to the boiler. A once-through flow of condenser cooling water of 11 m^3/s is drawn from Lake Erie and returned directly to the lake, up to 12.5^{o}C warmer.

The fuel for the boilers is pulverized coal. At full load each unit burns 170 Mg/h. The total consumption for 1983 was 6.37 million tonnes. The coal burned at Nanticoke is a blend of Eastern US (Appalachian) bituminous (2.5% sulphur, 10% ash) and Western Canadian (Alberta, British Columbia) bituminous coal (0.3% sulphur, 12% ash).

Coal is delivered by self-unloading lake freighters and stored in separate piles. Measures to control fugitive dust emissions from the coal handling operations and storage piles are implemented. The most successful among them are: water sprays, application of waste oil on heavily travelled areas and contouring the piles so that working areas are protected from the wind. These measures notwithstanding, strong winds coming off the lake still cause some coal (and ash) dust reentrainment.

The coal is blended in a 5,440 t/h blending plant, typically in a 50:50 US-Canadian mix. The mix ratio may change from 100% US coal to 40% US : 60% Western Canadian, depending on the availability of the coal. Blended coal is

fed into five in-plant, 227 tonne bunkers per unit. From the bunkers, it is fed into pulverizers, from which it is blown through 40 opposed burners into each boiler. Number 2 fuel oil is used to ignite the coal flames on startup and to maintain flame stability as required.

The combustion gases produced pass from the boiler through the economizer, which preheats the boiler feed water. The flue gases are cooled to 328°C in the economizer and then to 121°C in the regenerative air heaters which preheat combustion air. From the air heaters, the flue gases pass through the three-stage electrostatic precipitators, which remove 99.5% of the suspended particulate matter (fly ash). Induced draft fans draw the flue gases from the precipitators to the stacks. The ducts leading to the stacks are equipped with opacity monitors to indicate that levels of particulate matter emissions are acceptable.

The eight units are served by two 198 m high multi-flue stacks, located 275 m apart centre to centre. Each stack contains four flues, one flue per unit. The outer diametre of each flue is 5.5 m and at full load, each has a gas flow rate of 43 300 m^3/min, at 121°C, giving an exit velocity of 30.5 m/s.

The uncombusted portion of the coal (mineral matter and small amounts of carbon) creates two different types of ash. About 15% forms slag-like deposits on boiler surfaces and is removed through the bottom of the boilers (bottom ash). The

balance of 85% remains suspended in the flue gases as fly ash, and 99.5% of this is collected by the electrostatic precipitators.

Ash collected from the bottom of the boilers, economizers, and precipitators is sluiced to settling cells, located in what was formerly a 76 hectares on-site disposal lagoon. Runoff from the coal storage areas and effluents from the station's water treatment plant are also pumped to the same cells. Clarified effluent from the cells is discharged to the condenser cooling water outfall.

Virtually all the sulphur in the coal is emitted as sulphur dioxide. Very little sulphate or SO_3 is formed and only about 1% of the sulphur is retained in the ash.

Nitric oxide is formed during combustion as nitrogen in the fuel and combustion air combine with oxygen at high temperatures. The amount of nitrogen oxide formed is a function of the temperature of the flame and the mixing pattern of the burning gases. Ontario Hydro has installed new, low NO_x burners on three units. They reduce NO formation by at least 25% through lower flame temperature.

3.1.2 - STELCO

STELCO's Lake Erie Works is the second major industrial operation situated in the Nanticoke area. This basic steel plant is located on 1660 hectares of land on the north shore of Lake Erie, immediately west of the Village of Nanticoke.

A further 1100 hectares of land immediately north of the basic steel plant is the site of an industrial park for secondary industry. A short description of the facility, based on information supplied by Stelco[3] appears below.

The steel plant was designed with an initial capacity of 1.17 million tonnes per year. The first units of the plant were put into operation in June of 1980. Subsequent units were completed in November 1981 and June 1983.

Raw materials, coal and iron ore, are brought to the area by self unloading ships. The receiving dock, which extends 1191 m into Lake Erie, has a receiving hopper and conveyer system for material transport. The conveyer delivers the materials to the automatic stacking facility.

From storage, coal is transported by scrapers and a conveyer system to the coke ovens. The coke oven battery has 45 ovens, 6.7 m tall. During the coking process, coal is heated at 1400^{o}C for a duration of 16 to 17 hours. Heating is indirect, with gas burners situated in compartments in between ovens.

During coking, the organic components of coal are expelled and undergo chemical reactions which have as an end result the formation of a gas with high calorific value, a liquid with a water phase and an immiscible organic phase. The remaining solid - coke - is discharged from the oven into a hooded railway car and quenched with water, in a tower adjacent to the battery. This coke is then used as a

fuel source and reductant in the blast furnace. Part of the gas (about 60% hydrogen and 30% methane) fuels the coking battery and the remainder is sent to boilers in the Power Station. The liquid components are treated and separated in an adjacent chemical by-products plant.

Coke, iron ore pellets, and dolomite (plus some other ingredients of lesser tonnage, i.e. scrap iron, etc.) are conveyed to the blast furnace which has an ultimate capacity to produce 5 450 t/day of molten iron. Hot air, blown into the base of the furnace, oxidizes the coke to CO which in turn reduces the iron oxide in the ore to metal. At the temperature in the furnace, the metal, as well as, the slag (formed in the reaction of the gangue with the flux), are liquid; They are periodically tapped out. The gas which exits the blast furnace contains a large percentage of CO and thus, has a relatively high calorific value (although much lower than natural gas or coke oven gas). It is used as fuel in the Power Station and Blast Furnace Stoves.

From the Blast Furnace, molten iron is carried in insulated torpedo railway cars to the steel making shop where it is charged into two 230 t capacity basic oxygen furnaces. After mixing the molten iron with scrap iron, fluxes, and additives, oxygen is blown into the melt. In a violent reaction, the excess carbon is burned; impurities are also removed during the redox reactions taking place. The desired steel composition is reached in a relatively short time, i.e. an hour or less. Molten steel from these

vessels is transferred to a continuous casting process.

The casting complex consists of two casting strands in which the molten steel is solidified into steel slabs. This facility has a design capacity of 1.17 million tonnes per year. Slabs cast here may be sold, sent to another works or transferred by mobile vehicle to the hot strip mill.

The hot strip rolling facility reheats the slabs to the desired rolling temperature for converting them into thin strip. The strip is coiled for sale or further processing.

The steam and heat requirements of the plant are satisfied internally, by the Central Power Station. Here, two boilers with a steam capacity of 160 t/h each are fired with coke oven gas, blast furnace gas, natural gas, No.6 bunker C oil or any combination thereof (but in the order of preference as listed). Two new boilers, fired with No. 6 fuel oil and coke oven gas were added in 1985.

The Lake Erie Works is equipped with many service shops for maintenance purposes. They include a machine shop, a boiler shop, electrical repair shop, and a mobile equipment centre.

The plant has state-of-the-art environmental control facilities. Process water is recycled to a high degree before secondary treatment in the blowdown treatment plant and a final settling lagoon before discharge. Air cleaning equipment has been installed on the Blast Furnace and the Basic Oxygen Furnaces. There is also collection of the

secondary emissions which occur due to the processes. In addition, a detailed landscaping plan has been implemented. This includes earth berms up to 10 m high surrounding the plant, water filled lagoons and extensive tree planting.

Emissions from various sources differ greatly in type and magnitude.

The power station has typical boiler-associated emissions, i.e.: particulate matter, sulphur oxides and nitrogen oxides, but their levels are relatively low for such operations, due to the very clean fuels employed. Nevertheless, being uncontrolled, they represent, together with the Coke Oven Underfiring Stack, the major contributors to the total overall emissions for these three contaminants at Stelco.

The coking battery has some fugitive emissions generated during coke and coal handling. Door leaks are a source of continuous fugitive emissions. A flare, periodically burning excess gas, is uncontrolled.

Emissions generated during coke pushing are controlled with a travelling hood ventilation system which is positioned over the railway car in which hot coke is pushed. Dust generated in the process is removed in a medium energy venturi. Some fugitive emissions escape this dust collection system.

Another source of emissions in the area is the quench tower. The water vapour, generated during the short but violent quenching of the hot coke, entrains, in its upward

raise, a significant amount of coke fines. Some of the particles are stopped by a system of baffles in the tower but the finer ones escape to the atmosphere.

The Blast Furnace Stoves exhaust a large volume of flue gases. The fuel they burn is Blast Furnace off-gas, relatively clean. As a result, SO_x and particulate matter emissions are relatively low. Due to the particular combustion systems used, NO_x emissions out of this source are larger than from similarly sized straight combustion sources.

The Basic Oxygen Furnace, with its short operating cycle, emits a variable amount of contaminants i.e.: large amounts while oxygen is blown, less otherwise. Wet scrubbing of gas removes most of the contaminants.

3.1.3 - TEXACO

The Texaco refinery at Nanticoke is situated in close proximity to the Ontario Hydro generating station and Stelco's Lake Erie Works.

The refinery is capable of processing 105,000 barrels per calendar day of Light Western Canadian crude oil. It is a fully integrated refinery and comprises the following process units: Crude and Vacuum Unit, Fluidized Catalytic Cracking Unit, Catalytic Reforming Unit, Alkylation Unit, and Sulphur Recovery Unit. Other major operating facilities

include the Steam Plant and the Waste Water Treatment Plant. A description of processes and operation, from data supplied by the company[2], follows.

The Crude and Vacuum Unit constitute the first stage of processing, where crude oil is thermally separated into various fractions using an atmospheric tower and a vacuum tower. These fractions include gases, final products, referred to as straight-run material and streams requiring further processing.

The Fluidized Catalytic Cracking Unit receives heavy distillates from the Crude and Vacuum Units and catalytically cracks the stream at high temperatures (480 ^{o}C to 540 ^{o}C). Upon completion of the reactions, the cracked hydrocarbon vapours pass to a fractionating column where they are distilled into gases, light-ends, gasoline components, middle distillates and heavy distillates (residuals).

Spent catalyst, deactivated during the cracking process, is continuously transferred to a regenerator. There, carbon residue, called coke, which deposits on the catalyst particles during the cracking reaction, is burned off. The reactivated catalyst is then recycled back to the cracking process. Particulate matter, carbon dioxide (complete combustion of coke is induced through high temperature regeneration under a catalyst "promoted" state, eliminating carbon monoxide emissions), sulphur oxides, and nitrogen oxides are emitted to the CO Boiler from the

regenerator, as a consequence of coke combustion.

The Catalytic Reforming Unit takes low octane naphtha from the Crude Unit and catalytically transforms the stream, under high temperature (480°C to 540 °C) and low pressure (1.38 MPa), into high octane products. They are used as gasoline components. Side reactions lead to the formation of gases and light products. The catalyst activity deteriorates slowly and requires in-situ regeneration periodically. Basically, the regeneration consists of burning carbon off the catalyst and reactivating the catalyst sites through oxidation and reduction steps.

The Alkylation Unit combines the C3 and C4 olefin streams from the Fluid Catalytic Cracking Unit with isobutane, using sulphuric acid as a catalyst, to form a high octane product used as a component of gasoline. The sulphuric acid is continually withdrawn and replenished in order to maintain the minimum strength required to promote the desired reactions.

The Sulphur Recovery Unit removes hydrogen sulphide from the sour (i.e.: containing H_2S) gas streams and process water using an Amine Recovery Unit in conjunction with a three stage Claus Unit. The streams thus treated are the fuel gas and the gases and light (liquid) ends of the Crude Unit and the Fluid Catalytic Cracking Unit. The H_2S laden amine streams are regenerated (i.e. H_2S is removed) by stream stripping and recycled for further gas absorption.

Acid gas, resulting from steam stripping, is charged to the Claus Unit where a portion is thermally reacted with air, to form SO_2 and elemental sulphur. After condensation and removal of the liquid sulphur, the remaining gas proceeds through a series of three reactors where, in the presence of slipstreams of the remainder of the original acid gas, it is catalytically converted to sulphur and water. 95.5% of the sulphur in the unit feed is recovered as liquid elemental sulphur. The gas effluent from the third stage (tail gas) is sent to an incinerator to oxidize all remaining H_2S and other sulphur compounds. At the time of testing, the off-gas from the sour-water stripper was charged directly to the incinerator (by-passing the Claus Unit). After modifications made in 1985 this stream is now handled by the Claus Unit.

Gaseous effluents generated by all the refinery processes are released to the atmosphere through ten stacks; the majority are exhausts from heaters of different process units in the refinery. Six of the sources are flues contained in a large concrete structure designated as the Multiflue Stack; the remaining four stand as independent sources. The flues situated in the Multiflue Stack, which is 112 m high are for:

1 - the Crude and Vacuum Heaters (3.5 m I.D.);

2 - the Fluid Catalytic Cracking Unit Charge Heater (1.9 m I.D.);

3 - the CO Boiler (4.1 m I.D.);

4 - the No. 1 Power Boiler (2.6 m I.D.);

5 - the Nos. 2 and 3 Power Boilers (3 m I.D.);

6 - the Fluid Catalytic Cracking Unit Regenerator (on standby) (2.5 m I.D.).

The independent stacks are the Unifiner Charge Heater (54 m height and 1.4 m I.D.), the Combined Stack (56 m height and 2.1 m I.D.), the Platformer Charge Heater (104 m height and 3.3 m I.D.), and the Sulphur Recovery Unit Incinerator Stack (91 m height and 0.9 m I.D.).

Emissions vary between stacks. Process heaters and boilers burning strictly fuel gas will have similar emissions. As well, heaters and boilers burning strictly fuel oil will have similar emissions. Emissions from fuel oil burning though, will differ from emissions from fuel gas burning due to the different sulphur content of the two fuels (up to 1.5% sulphur in fuel oil versus no sulphur in fuel gas).

The Sulphur Recovery Unit Incinerator Stack and the CO Boiler, each have emissions which differ from those of the process heaters and power boilers, due to their unique functions. The emissions from the incinerator will be dependent on the quality of the Sulphur Recovery Unit tail gas and Sour Water Strippers off gases.

The CO Boiler emissions are dependent on the quality of the Fluid Catalytic Cracking Unit fresh feed and the operating efficiency of the cyclones in the Regenerator

section; three stages are used to minimize the emissions to the atmosphere.

Other sources of emissions are the tank farm (product storage) and the Waste Water Treatment Plant (oils recovery), where light hydrocarbons escape to the atmosphere through vaporization. The vapour losses are minimized by floating roofs in all gasoline and gasoline component tanks and covers for the primary separator basins at the Waste Water Treatment Plant.

Fugitive emissions of light hydrocarbons from valves, seals and leaks in any process and/or transfer equipment could be a potentially considerable component of the total emissions of hydrocarbons from the refinery.

4 - DISCUSSION OF SAMPLING METHODS

This chapter refers to sampling performed by or at the request and under the direct supervision of the Source Measurement Unit of the Ministry of the Environment.

4.1 - PARTICULATE MATTER

Tests for particulate matter have been performed on sources at both Stelco and Texaco. At Texaco, both total particulate matter and size distribution have been measured whereas at Stelco, there was no attempt made to determine size distribution.

The method for total particulate matter is described in the Ontario Source Testing Code[5]. Gas withdrawn isokinetically from a grid of points across a section of the exhaust stack had its particulate content separated by filtration. Gravimetric analysis of the filter and direct measurement of stack gas flow rate produced emission rate values.

One of the sources at Stelco, the Quench Tower, raised unusual problems due to its size, liquid carry-over and cyclical operating schedule. This called for some innovative changes in the sampling method to obtain representative results.

Velocity across the eighty-two square meters

rectangular structure was determined at twelve points (three by four grid) with an instrument capable of recording the instantaneous velocity for the duration of each quench; for each point, two quenches were recorded and their average was used .

Sampling rate was adjusted at each point, for the duration of each run (six and a half minutes) using the velocity obtained as described above. Two trains, running in parallel, sampled sequentially six (each) of the twelve points in the grid. One run consisted of the average of the results obtained by the two trains. Three such runs constituted a valid test. Details appear in the final report of the consultant who did the field work[6].

Particle size distribution has been determined at the stack of the Fluid Catalytic Cracking Unit of Texaco[15], by sampling at single point with a Mark I Andersen in-stack impactor.

Ontario Hydro's emissions of particulate matter[9] have been estimated by the company from analysis of the ash content of the fuel, the amounts of bottom ash removed and the efficiency of the electrostatic precipitators.

4.1.1 - PARTICLE SIZING

The particle size distribution has been determined in one series of tests carried out at the stack of the Fluid Catalytic Cracking Unit at the Texaco refinery. An in-stack

Andersen impactor has been used for the purpose. Tests consisted of single point sampling, at a central location for thirty consecutive minutes. Three runs were performed. The aerodynamic diameter of the particles collected was determined from the weight distribution of the catch on the different plates of the impactor (the smaller the particles, the deeper they deposit inside the impactor).

4.1.2 - TRACE ELEMENTS

Particulate matter collected in several of the stack sampling tests has been analyzed in detail for a series of elements expected to appear in trace amounts. They are: Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Sr, Ti, V, and Zn. The quantification of most has been done by atomic absorption spectrophotometry (after acid digestion of the catch). Arsenic and selenium have been determined as hydrides (also by AA) and boron has been determined by inductively coupled plasma emission spectroscopy.

4.2 - SULPHUR DIOXIDE

The sampling for sulphur oxides performed at both Texaco and Stelco has been done as per the specifications of the EPA standard method[7]. Gas withdrawn from a single point

in the stack was passed through a solution which absorbed SO_2. Subsequent analysis of the solution by ion chromatography quantified the amount.

At Stelco, a continuous emission monitor in the mobile laboratory of the Source Assessment Unit has been used in parallel with the consultant's sampling train. The instrument used by the Stationary Source Emission Monitoring Unit (SSEMU) is a non dispersive ultra-violet analyzer, Western Research Model 721.

The sulphur dioxide emissions of Ontario Hydro have been obtained from the company by mass balance. The sulphur content of the coal has been routinely determined and the assumption made that all the sulphur will appear as SO_2 in the flue gas. This is a slight overestimation because a few percentage points of the element is fully oxidised to SO_3 and a small fraction of the total sulphur will be retained in the ashes as sulphate.

4.3 - NITROGEN OXIDES

The method used for nitrogen oxides sampling at both Stelco and Texaco involved the collection of a known volume of stack gas in a vessel containing an absorbing solution specific for nitrogen oxides. Quantitation was done by ion chromatography.

At Stelco, a continuous emission monitor in the mobile laboratory of the Source Assessment Unit was used in

parallel with the consultant's sampling train. The instrument used by SSEMU is a Thermo Electron Co. Model 10A instrument using the chemiluminescence of the ozone - nitrogen oxide chemical reaction.

Ontario Hydro made their own measurements of nitrogen oxide concentration in the Nanticoke TGS flue gas. All the numbers quoted for this industry are based on these measurements.

4.4 - HYDROCARBONS

Testing for hydrocarbons took place at the tank farm of the Texaco refinery[16]. An instrument with a flame ionization detector was used in-line with the sampling pump for on-site determination of total hydrocarbons. The concentrations obtained, together with the tank "breathing volume", estimated by Texaco, produced a figure for total emissions. Information regarding the exact composition of the hydrocarbon vapours was obtained by the gas chromatographic analysis of samples (obtained at the same time) in glass bulbs. The Organic Trace Contaminants Section of the Ministry's Laboratory Services Branch performed the analysis.

Emissions of polyaromatic hydrocarbons from the flue of one unit at Nanticoke TGS, running at full capacity, were quantified by Battelle in a study carried-out for the Canadian Electrical Association[10].

5 - EMISSION RESULTS

The results reported are mainly those that were obtained by and/or under the direct supervision of the Ontario Ministry of the Environment, as part of the NEMP Programme. To the extent that they are helpful in understanding the significance of the numbers reported, in the context of the overall emission levels from the entire industrial area, results of sampling performed by or for the Companies themselves are also reported.

Table No.1 summarizes the emissions of particulate matter, sulphur oxides, nitrogen oxides and hydrocarbons from the three main industrial operations in Nanticoke. It should be noted that some of the numbers presented here, based on source testing, represent the situation at sampling time. Variations in fuel rate/process rate might cause the yearly average emission rates reported by the industries themselves to be different from the findings.

Ontario Hydro's estimate is for year 1983, during which the generating station was operated at fifty-three percent of its rated capacity.

The results reported for Stelco are a composite of numbers determined by stack sampling and Company estimates (derived from emission factors). The total 1983 steel production (slabs) of Lake Erie Works was 1,180,144 tonnes.

Production at Texaco was constant during 1983, at an average of ninety-two thousand (92,000) barrels per day.

5.1 - PARTICULATE MATTER

Sampling for total suspended particulate matter has been undertaken at several sources within Stelco and Texaco. In the results reported for particulate matter, the material caught in the impingers, i.e. past the filter, has not been considered.

The catch in the sampling train has been analyzed for trace elements (at selected sources - results reported in section 5.4). Recognizing that considerable enrichment in light fractions can occur and that the effect of a particular trace element can be much more important than the effect of total particulate matter in general, the content of the impingers has been analyzed for trace elements and the results have been included in the total emissions.

Particle size distribution has also been determined at the most important sources.

Ontario Hydro reported their estimate of total emissions and the numbers are reproduced as such. These numbers are not the result of stack sampling as defined by the Ontario Source Sampling Code but rather estimates derived from emission factors for the average operating levels throughout the year. The accuracy of these numbers, backed by some independent tests, is nevertheless adequate for yearly estimates.

Total particulate matter emissions from stacks of the three industries located in Nanticoke are close to four thousand (4,000) tonnes per year (1983).

5.1.1 - ONTARIO HYDRO

Total emissions of particulate matter from the two multiflue stacks were estimated in 1983 (year during which the power plant operated at 53 % of its rated capacity) at 2500 t/year[9]. Previous two years estimates are close, at 2400 t/year. The basis for these numbers is the analysis of the ash content of the coal. From total coal consumption and knowledge of the fly/bottom ash distribution (85%/15%) and the efficiency of the electrostatic precipitators (99.5%), a fairly good estimate can be derived. Stack testing performed in 1982, by an independent contractor, produced numbers[10] which are very close to Ontario Hydro estimates (after correcting for average operating power levels during the whole year).

There is limited information regarding the size distribution of the particulate matter emitted from this power plant. Samples were obtained in a study which attempted to establish levels of trace constituents emitted from the source and their enrichment factor in different fractions[10]. A five cyclone separator was used to draw gas from the stack inlet duct at one of the generators working at full (505 Mwe) capacity. The suspicion exists that the

ESP was operating at less than optimal efficiency and that the "large" fraction (i.e. greater than 7.5 microns stage) is larger in weight than what would have been produced under normal conditions. Plotting the numbers obtained, one arrives at a 50% cut-off aerodynamic diametre (i.e. 50% of the mass is present as particles smaller in size) of 10 microns.

5.1.2 - STELCO

The sources at Stelco's Lake Erie Works have been evaluated from data existing in Ministry files, as well as information provided by the Company, in order to ascertain which would be the major contributors to the total emissions of the plant. An estimate made by the Company[14] puts the total atmospheric releases from confined sources in their Lake Erie Works at 49.1 kg/h. This refers to year 1983 at a total production of 1,180,144 tonnes steel (slabs).

Out of a list of nineteen different sources, five were singled out for a comprehensive survey carried out by the Ministry on the behalf of NEMP. Three of these five have been sampled for particulate matter. A sixth stack (the Basic Oxygen Slab Casting OG Stack), has been sampled by a consultant for the Company and the results obtained are reported here as well.

The sources sampled represent a total of approximately

half of the estimated emissions of particulate matter. Based on results obtained (with the assumption that the other stacks emit as estimated by Stelco) the sources examined represent over two thirds of the total. The proportion is expected to change relatively little with changes in production.

Table No. 2 contains a summary of the findings.

Direct sampling has produced numbers which are generally higher than the estimates derived from emission factors. The overall emissions of the major sources sampled add up to 27.4 kg/h (time averaged) which is considerably higher than the 15.7 kg/h yearly average estimated by Stelco (see cautionary note in section 5).

The largest difference between pre-test, average estimates and actual findings (the one which has most impact on the overall level of emissions from STELCO), is the one noted for the Coke Oven Quench Tower. It is more than three times larger than what the Company expected.

No particle size distribution measurements have been attempted at STELCO. Visual observations at the largest source, the Coke Oven Quench Tower, concluded that a great fraction of the number of particles carried up by the steam puffs is quite large in size (larger than 10 microns). It accounts, probably, for most of the mass emitted.

5.1.3 - TEXACO

The Nanticoke Refinery has five main stacks, one of them a multiflue with six flues enclosed in a common containment structure. All carry combustion products. The types of operations that they serve are steam generation (boilers), process heating (charge heaters), and burning carbonaceous deposits off the surface of spent catalyst (FCCU CO Boiler). A one of a kind operation, discharging through the Sulphur Recovery Unit Stack, is an incineration process which transforms any residual hydrogen sulphide into sulphur dioxide.

In a survey carried out by Arthur Gordon for NEMP, under the supervision of the Ministry, sources representative of the main operations of the plant have been sampled for their principal contaminants[15]. Total particulate matter levels have been determined in the exhaust from the No. 1 Power Boiler and the CO Boiler. Results of the survey are summarized, together with similar numbers estimated by the Environmental Approvals and Project Engineering Branch of the Ministry for the other sources at the Nanticoke Refinery, in Table No. 3 (see cautionary note in section 5).

From the results of the survey, and using Ministry estimates for the stacks not sampled, the total annual (1982) emissions of particulate matter from confined sources within the Texaco Refinery in Nanticoke add up to

approximately 1,400 tonnes.

The particle size distribution of the material emitted from the CO Boiler has been determined by in-stack fractionation with a nine-stage Andersen impactor. The aerodynamic diameter, determined as an average of three tests, was 2.3 microns[15].

5.2 - SULPHUR DIOXIDE

The Ministry did not conduct or sponsor tests for sulphur dioxide at Ontario Hydro. Their emissions are estimated on the basis of daily analysis of the coal and knowledge of the distribution of the combustion products between the different effluent streams. Important sources have been tested at Stelco and Texaco.

Total emissions from the stacks of the three industries located in the Nanticoke area are close to a quarter of a million (250,000) tonnes SO_2 per year (1983).

5.2.1 - ONTARIO HYDRO

The total emissions of sulphur dioxide from the two multiflue stacks were estimated in 1983 at 199 000 t/year[9]. Previous two years estimates are close. The basis for these numbers is the analysis of the coal and ash. From total consumption and knowledge of ash composition, emission rates of sulphur dioxide can be made with good accuracy.

5.2.2 - STELCO

Stelco's own estimates[14] for their atmospheric emissions of sulphur dioxide from all their confined sources total 2,492 tonnes for year 1982 and 2,949 tonnes for year 1983. This is based on their steel production (slabs) of 763,917 t in 1982 and 1,180,144 t in 1983, respectively.

The three most important sources (out of a list of seven), i.e.: the Central Power Station Boilers, Coke Ovens Underfiring and the Blast Furnace Stoves, account for more than two thirds of the total emissions (of sulphur oxides) from the Lake Erie Works. They have been sampled in a programme undertaken by NEMP. A fourth source, the Basic Oxygen Slab Casting OG stack has been sampled by a consultant for the Company. Process emissions from this last source have been found negligible and are not included in this report. Results for the other sources are presented in Table No 4.

Results produced by actual stack sampling exceed Stelco's estimates in all cases (but see cautionary note on page 28). If sulphur trioxide emissions are included in calculations, findings for the three stacks in question add up to a total emission rate of sulphur oxides of 200 kg/h, compared with Company's estimate of 117.7 kg/h. If sources identical with the ones sampled are also considered (i.e. both Boilers and all Blast Furnace Stoves), emissions based

on tests for the three types of sources amount to a total of 328.7 kg SO_x/h (compared with previously available estimates of 204.1 kg/h).

5.2.3 - TEXACO

The total yearly atmospheric emissions of sulphur dioxide from confined sources at the Nanticoke Refinery of Texaco, according to best available estimates and results of stack testing performed in 1982, amount to 14,278 tonnes.

The largest source is the CO Boiler. Second in importance are the Power Boilers. The third largest source is the Sulphur Recovery Unit stack. All three have been tested[15] in a NEMP sponsored programme, under the supervision of the Ministry. Results are summarized in Table No. 3 (see cautionary note in section 5).

5.3 - NITROGEN OXIDES

There have been attempts to determine nitrogen oxides emissions by direct sampling through programmes performed under the direct supervision of the Ministry at the major sources at Stelco and Texaco. The results obtained at Stelco are inconclusive. The emissions of Ontario Hydro are reported by the Company, based on emission factor calculations (supported by internal verifications).

It is estimated that the total annual emissions of nitrogen oxides from the stacks of the three industries located in the Nanticoke area is close to eighty thousand (80,000) tonnes NO_2 (1983).

5.3.1 - ONTARIO HYDRO

The Company reports to the Ministry its annual emissions of nitrogen dioxide. They are based on emission factors developed following in-house tests conducted at each unit at Nanticoke TGS. It is estimated that during 1983 the total atmospheric emissions from the two stacks at Nanticoke Generating Station amounted to 75,133 tonnes[9].

5.3.2 - STELCO

Stelco's emissions of nitrogen oxides are caused by fuel burning in boilers and other heating equipments, e.g.: preheaters for the blast furnace air. Total atmospheric emissions for 1983 have been estimated[14] by the Company to have amounted to 2,012 tonnes.

A list of all the confined sources in the Lake Erie Works contains nine entries. Out of these, the largest are the Power Station Boilers, the Coke Oven Underfiring and the Blast Furnace Stoves. Together, they amount to about ninety percent of STELCO's estimated emissions of NO_x. Because of their magnitude, these three sources were selected for direct stack sampling in a programme carried out under NEMP.

Tests performed by Arthur Gordon for NEMP were affected by undetermined field collection and/or analytical errors. The numbers obtained by them are considered unreliable.

The Ministry Stack Sampling Mobile Monitoring Unit did sample the same three sources in parallel with the consultant. The methods used by the Ministry team relied on continuous instrumental monitoring of the in-stack conditions. Their results are presented in Table No. 5 (see cautionary note in section 5). There is a good degree of confidence in the numbers obtained by the Mobile Monitoring Unit. The precision and accuracy of its instruments are continually verified through checks and calibrations.

5.3.3 - TEXACO

The largest confined sources of nitrogen oxides emissions at the Nanticoke Refinery of Texaco are the boilers and different process heaters. The CO Boiler and one of the Power Boilers have been tested in 1982 by A. Gordon, in a programme sponsored by NEMP and conducted under the supervision of the Ministry. Results are presented in Table No. 3 (see cautionary note in section 5).

The total yearly atmospheric emissions of nitrogen oxides from the Nanticoke Refinery, based on best available estimates and 1982 stack sampling results, amount to 2 448 tonnes.

5.4 - TRACE ELEMENTS

Trace elements have been measured in the airborne particulate matter collected by high volume samplers at several automatic sampling stations in the Nanticoke area. Particulate emissions from local sources were analyzed for their trace elements content to determine whether there is a correlation with the high volume sampler results.

Samples obtained at different sources have not been necessarily assayed for the same list of trace elements, nor have the same methods been used for particular elements. The

analysis has been done after considering the importance of the source in terms of each element and the analytical capabilities of the laboratory performing the work.

5.4.1 - ONTARIO HYDRO

Because modern coal-fired generating stations are equipped with efficient particulate recovery devices, only small amounts of trace elements (and other constituents sorbed onto particles) are released into the atmosphere through the stacks. Annual deposition is expected to be only a few grams per hectare per year, even for the most abundant elements, at their zones of maximal deposition.

Ontario Hydro conducted studies on trace element content of both eastern US bituminous[11] and Western Canadian[12] coals. Results permitted an evaluation of the range of the emissions based on enrichment factors in flue ash derived for each element and the distribution of flue/bottom ash.

A more accurate determination of actual emissions of trace elements has been performed in 1982 by Battelle[10] during their study on such emissions from Canadian coal-fired power plants. Maximum atmospheric releases have been estimated from the average results obtained over three sampling runs, conducted one per day, and are presented in Table No. 6.

5.4.2 - STELCO

All particulate matter samples collected at STELCO were analyzed for their trace elements content.

The Central Power Station Boilers are similar in their emission levels to the Coke Oven Pusher Scrubber. At the time of the tests the fuel to the Boiler was a mixture of Coke Oven and Blast Furnace gas in the volume ratio 1:28.

The Coke Oven Quench Tower has emissions which are, depending on the element considered, up to one order of magnitude higher than the other two sources. The Tower has been sampled both at the top elevation and under a set of baffles designed to trap most of the droplets and larger particles rising with the hot steam/gas. The efficiency of the baffles in capturing particulate matter was found to be about sixty percent. This percentage reduction is not duplicated for all the contaminants analyzed. The accuracy of some of the results obtained is doubtful (emissions higher above baffles than below).

The results are summarized in Table No. 7.

5.4.3 - TEXACO

Arthur Gordon performed stack sampling at three major sources in the refinery during the fall of 1982. Particulate matter collected during source sampling at both the CO Boiler and No. 1 Power Boiler of the Nanticoke Refinery of

Texaco was analyzed for a list of trace elements.

The Power Boiler was tested while fired with No. 6 fuel oil. With few exceptions, its hourly emissions are about four times lower than those of the CO Boiler. Results of the tests are summarized in Table No.8.

5.5 HYDROCARBONS

The major source of hydrocarbons in the Nanticoke area is the 105 000 barrels per day refinery owned and operated by Texaco Canada Inc. A second source,, considered of lesser importance, is the chemical plant associated with the coking operation at Stelco's Lake Erie Works. Coke Ovens Battery door leaks could be a significant source of fugitive emissions.

Hydrocarbons are of concern mainly in the context of their involvement in the creation of photochemical smog. On days with high insolation levels and in the presence of significant amounts of nitrogen oxides, this possibility is to be taken into account even for areas situated at relatively high latitudes (as Nanticoke is).

5.5.1 TEXACO

Based on a literature survey, it was concluded that the tank farm could be responsible for over half of the

hydrocarbons emissions from the refinery. A study to examine the emissions from the tank farm in the Texaco refinery was conducted for NEMP, by personnel of the Source Assessment Unit of the Ministry of the Environment[16], in the summer of 1979.

Eight tanks were carefully chosen such that their emissions were representative for total hydrocarbon emissions from ninety percent of the tank farm. Sampling and analysis were performed simultaneously by using a continuous emission monitor equipped with a flame ionization detector (FID). The response of this instrument is a function of the number of carbon atoms present in the molecule of the hydrocarbon, but is otherwise non-specific. Samples taken in parallel, in glass bulbs, have been speciated and the components quantified by gas chromatography. This procedure however, accounted for only a minor percentage of the total amount of hydrocarbons detected by the FID.

The hydrocarbon emissions from the Texaco refinery tank farm totalled 106.22 tonnes per year. This number represents an average based on the concentrations detected in summertime and, as such, it may be an overestimate of the actual situation. It is also based on the filling and emptying schedule of the tanks observed at sampling time and thus, on the "breathing losses" associated with that particular operating schedule.

The following tables summarize the numeric data discussed in the report.

TABLE No. 1

Summary of atmospheric emission rates of particulate matter, sulphur dioxide and nitrogen oxides from the three major industries in the Nanticoke area.

POLLUTANT	EMISSION RATE - (kg/h)			
SOURCE	ONTARIO HYDRO[a]	STELCO[b]	TEXACO[c]	TOTAL
Part. matter	285.4	52.0	88.8	426.2
Sulphur oxides[d]	22,716.9	388.9	1,629.9	24,735.7
Nitrogen oxides[e]	8,576.9	286.6	279.4	9 142.9
Hydrocarbons[f]	-	-	12.1	12.1

a - Ontario Hydro's own estimate[9] for 1983.

b - Total calculated - adding emissions as determined (for sources actually sampled) and as estimated by the Company[14] for 1983. Numbers have been time averaged; for intermittent operations the correction factor was the ratio of the "on" to the "off" time (sampling took place only during "on" periods).

c - Total calculated - adding emissions as determined (for sources actually sampled) and as estimated by MOE[15] for 1982.

d - Expressed as SO_2.

e - Expressed as NO_2.

f - Expressed as propane.

TABLE No. 2

Atmospheric emissions of particulate matter from selected sources at STELCO's Lake Erie Works in Nanticoke.

SOURCE	EMISSION RATE[a] INSTANTANEOUS (kg/h)	TIME AVERAGED[b] (kg/h)	STELCO ESTIMATE[c] (kg/h)
Central Power Station No.2 Boiler[d]	8.3	8.3	8.2
Coke Oven Pusher Scrubber	2.1	0.4	1.0
Coke Oven Quench Tower	57.4	17.2	5.3
Basic Oxygen Slab Casting Furnace[e]	6.7	1.5	1.2
Total	74.5	27.4	15.7

a - As measured by Arthur Gordon for NEMP[6] in 1983 (except as otherwise noted).

b - For intermittent operations the correction factor was the ratio of the "on" to the "off" time (sampling took place only during "on" periods).

c - Estimate[14] of atmospheric emissions in 1983, for a total steel production of 1,180,144 tonnes.

d - One of two identical. For total emissions for this type of source multiply by two.

e - This source has been sampled by ORF[13] for Stelco (in 1981); there are doubts that the averaging, as proposed by the consultant, underestimates reality.

TABLE No. 3

Atmospheric emissions of particulate matter, sulphur oxides and nitrogen oxides from confined sources at the Texaco Refinery in Nanticoke.

SOURCE POLLUTANT	EMISSION RATE - (kg/h) PART. MATTER	SO_2	NO_2
Crude and Vacuum Charge Heater	18.6	168.3	66.1
FCCU Charge Heater	4.0	36.4	14.1
CO Boiler	38.4[a]	856.1[a]	39.9[a]
No.1 Power Boiler	3.6[a]	207.9[a]	56.1[a]
No.2 and No.3 Power Boilers	18.7	174.2	72.6
Unifiner Charge Heater	0.2	0.0	1.3
Combined Stack	1.4	0.0	5.7
Platformer Charge Heater	3.9	0.1	22.7
Sulphur Recovery Unit Stack	-	186.9[a]	0.9
Total	88.8	1,629.9	279.4

a - As measured by Arthur Gordon for NEMP[15] in 1982. All others are estimates of the Environmental Approvals and Project Engineering Branch of the Ontario Ministry of the Environment.

TABLE No. 4

Atmospheric emissions of sulphur oxides from selected sources at STELCO's Lake Erie Works in Nanticoke.

SOURCE / POLLUTANT	EMISSION RATE[a] SO_2 (kg/h)	SO_3 (kg/h)	STELCO ESTIMATE[b] (kg/h)
Central Power Station No. 2 Boiler[c]	109.0	2.6	77.4
Coke Oven Underfiring	69.1	2.2	31.3
Blast Furnace Stoves[d]	12.2	4.9	9.0
Total	190.3	9.7	117.7

a - As measured by Arthur Gordon for NEMP[6] in 1983.

b - Estimate[14] of atmospheric emissions in 1983, for a total steel production of 1,180,144 tonnes.

c - One of two identical. For total emissions from this type of source multiply by two.

d - This results is for one Stove only. For total emissions from this type of source multiply by two as there are a total of three stoves which cycle on (two hours) and off (one hour) with two being on at any one time.

TABLE No. 5

Atmospheric emissions of nitrogen oxides from selected sources at STELCO's Lake Erie Works in Nanticoke.

SOURCE	EMISSION RATE (kg NO_2/h) MEASUREMENTS MOE[b]	A. Gordon[c]	STELCO ESTIMATE[a] (kg/h)
Central Power Station No.2 Boiler[d]	76.3	N.D.	71.7
Coke Oven Underfiring	78.5	12.1	24.2
Blast Furnace Stoves[e]	12.2	N.D.	31.0
Total	167.0	12.1	126.9

a - Estimate[14] of atmospheric emissions in 1983, for a total steel production of 1,180,144 tonnes.

b - MOE internal memo, results unpublished.

c - As measured by Arthur Gordon for NEMP[6] in 1983. Inaccurate results; affected by sampling and/or analysis errors.

d - One of two identical. For total emissions from this type of source multiply by two.

e - This results is for one Stove only. For total emissions from this type of source multiply by two as there are a total of three stoves which cycle on (two hours) and off (one hour) with two being on at any one time.

TABLE No. 6

Estimated maximum atmospheric emissions of trace elements from Ontario Hydro's Nanticoke Generating Station.

ELEMENT		EMISSION RATE[a] (kg/h)
Arsenic	(As)	0.026
Barium	(Ba)	0.330
Cadmium	(Cd)	0.001
Chromium	(Cr)	0.020
Copper	(Cu)	0.016
Fluorine	(F)	9.800
Mercury	(Hg)	0.015
Molybdenum	(Mo)	0.005
Nickel	(Ni)	0.013
Selenium	(Se)	0.140
Strontium	(Sr)	0.160
Vanadium	(V)	0.030

a - Sampling performed in 1982 by Battelle for CEA. Results are average of three runs over three day period (maximum firing rate, i.e. 500 MW) at Unit 2.

TABLE No. 7

Atmospheric emissions of trace elements
from selected sources at
STELCO's Lake Erie Works in Nanticoke.

ELEMENT		EMISSION RATE[a] - (kg/h)			
	SOURCE:	CPS[b]	QUENCH TOWER c	QUENCH TOWER d	PUSHER SCRUBBER
Aluminium	(Al)	0.0103	0.1230	0.1538	0.0037
Antimony	(Sb)	0.0000	0.0002	0.0002	0.0000
Arsenic	(As)	0.0005	0.0090	0.0548	0.0018
Barium	(Ba)	0.0007	0.0200[e]	0.0135	0.0003
Boron	(B)	0.0006	0.0112	0.0136	0.0011
Cadmium	(Cd)	0.0004	0.0020[e]	0.0014	0.0004
Calcium	(Ca)	0.0311	1.5138	3.6138	0.0403
Chromium	(Cr)	0.0398	0.0309	0.0311	0.0134
Cobalt	(Co)	0.0008	0.0031[e]	0.0011	0.0006
Copper	(Cu)	0.0036	0.0113[e]	0.0101	0.0027
Iron	(Fe)	0.6691	0.8011	0.9735	0.1184
Lead	(Pb)	0.0013	0.0188	0.0264	0.0508
Magnesium	(Mg)	0.0131	0.0994	0.1819	0.0052
Manganese	(Mn)	0.0101	0.0167	0.0186	0.0111
Molybdenum	(Mo)	0.0114	0.0042	0.0867	0.0023
Nickel	(Ni)	0.0501	0.0347	0.0504	0.0183
Potassium	(K)	0.0272	0.1630	0.2895	0.0221
Sodium	(Na)	0.0403	0.4227	0.6952	0.0340
Selenium	(Se)	0.0002	0.0004	0.0020	0.0001
Strontium	(Sr)	0.0013	0.0084	0.0143	0.0010
Titanium	(Ti)	0.0013	0.0169[e]	0.0136	0.0014
Vanadium	(V)	0.0006	0.0022[e]	0.0020	0.0002
Zinc	(Zn)	0.0207	0.4628[e]	0.2771	0.0331

a - Results are instantaneous emission rates; at the time when these numbers were obtained the time weighting factors for the Quench Tower and Pusher Scrubber were 30% and 21%, respectively.

b - Central Power Station Boiler (one of two identical).

c - Quench Tower - above baffles.

d - Quench Tower - below baffles; these are not emissions.

e - Result is doubtful.

TABLE No. 8

Atmospheric emissions of trace elements from selected confined sources at the Texaco Refinery in Nanticoke.

ELEMENT		EMISSION RATE - (kg/h)	
	SOURCE	CO BOILER	No. 1 POWER BOILER
Arsenic	(As)	0.0103	0.0026
Barium	(Ba)	0.0216	0.0070
Cadmium	(Cd)	0.0006	0.0001
Chromium	(Cr)	0.0210	0.0031
Cobalt	(Co)	0.0015	0.0005
Copper	(Cu)	0.0021	0.0008
Iron	(Fe)	0.3276	0.1103
Lead	(Pb)	0.0254	0.0060
Manganese	(Mn)	0.0023	0.0009
Nickel	(Ni)	0.0402	0.0450
Strontium	(Sr)	0.0125	0.0046
Vanadium	(V)	0.0298	0.0506
Zinc	(Zn)	0.0473	0.0148

REFERENCES

1.- Letter from N. Krishnamurthy, Ontario Hydro, August 15, 1984.

2.- Letter from R. Cameron, Texaco, April 3, 1984.

3.- Letter from H. Eisler, Stelco, October 19, 1984.

4.- M. Lusis, Air Quality and Management in the Long Point, Haldimand, Norfolk Area, Presented at the Workshop for Strategies for Environmental Management in the Long Point Area, Waterloo, March 6-8, 1980.

5.- Source Testing Code (Version #2), Report #ARB-TDA-66-80, November 1980.

6.- A. Gordon Environmental Evaluators Ltd., Emission Study at Stelco, Nanticoke, June, 1984.

7.- Method 6 - Determination of Sulfur Dioxide Emissions From Stationary Sources, CFR Title 40, August 18, 1977, (amended FR 39010 08/26/83 and FR 26522 06/27/84).

8.- Method 7A - Determination of Nitrogen Oxide Emissions From Stationary Sources, CFR Title 40, December 8, 1983.

9.- W. Perks, Estimates of Atmospheric Emissions from Ontario Hydro Fossil-Fuel-Fired Thermal Generating Stations During 1984., Ontario Hydro Report CTS-07120-1, February 28, 1985.

10.- J. Evans at al., Characterization of Trace Constituents at Canadian Coal-fired Power Plants, Phase I Final Report, Battelle Pacific Northwest Laboratories, January 1985.

11.- K. Curtis, Trace Elements Content of Eastern U.S. Bituminous Coals, Ontario Hydro Report No. 77-156-K, 1977.

12.- K. Curtis, Trace Element Content of Western Canadian Coals, Ontario Hydro Report No. 80-309-K, 1980.

13.- Determination of Pollutant Emission Rates During BOSC Oxygen Blowing, ORF Report P-3729/I, December 29, 1981.

14.- A. Schuldt, Letter to MOE (J.Cooke), April 24,1984.

15.- D. Maftei, Stack Emissions from Three Large Sources at the Texaco Refinery in Nanticoke, Ontario, Report #ARB-54-83-ETRD, August 1985.

16.- J. Marson, V. Ozvacic, A Preliminary Study of the Emissions of Hydrocarbons from the Texaco Refinery Tank Farm, Report #ARB-013-81-ETRD.